



US009048351B2

(12) **United States Patent**
Lai

(10) **Patent No.:** **US 9,048,351 B2**
(45) **Date of Patent:** **Jun. 2, 2015**

(54) **LED DIE, METHOD FOR MANUFACTURING THE LED DIE AND AUTOMOBILE LAMP HAVING THE LED DIE**

(58) **Field of Classification Search**

None

See application file for complete search history.

(71) Applicant: **HON HAI PRECISION INDUSTRY CO., LTD.**, New Taipei (TW)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2002/0134987 A1* 9/2002 Takaoka 257/98
2004/0188689 A1* 9/2004 Shono et al. 257/79
2011/0297953 A1* 12/2011 Lai 257/76

* cited by examiner

(72) Inventor: **Chih-Chen Lai**, New Taipei (TW)

(73) Assignee: **HON HAI PRECISION INDUSTRY CO., LTD.**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 14 days.

Primary Examiner — Yasser A Abdelaziez

(74) *Attorney, Agent, or Firm* — Novak Druce Connolly Bove + Quigg LLP

(21) Appl. No.: **13/935,530**

(22) Filed: **Jul. 4, 2013**

(57) **ABSTRACT**

An LED die includes a transparent substrate, an N-type layer, an active layer and a P-type layer successively arranged on a first surface of the transparent substrate. A part of the N-type layer is exposed. The LED die further includes an electrode structure arranged on the P-type layer and the exposed surface of the N-type layer. A light outputting surface is formed on a second surface of the transparent substrate. The light outputting surface is a smoothly concave and arc-shaped surface. An LED automobile lamp with the LED die and a method for manufacturing the LED die are also provided. The light outputting surface of the LED die directly faces a lens of the LED automobile lamp.

(65) **Prior Publication Data**

US 2014/0177246 A1 Jun. 26, 2014

(30) **Foreign Application Priority Data**

Dec. 24, 2012 (TW) 101149434 A

(51) **Int. Cl.**

H01L 33/00 (2010.01)

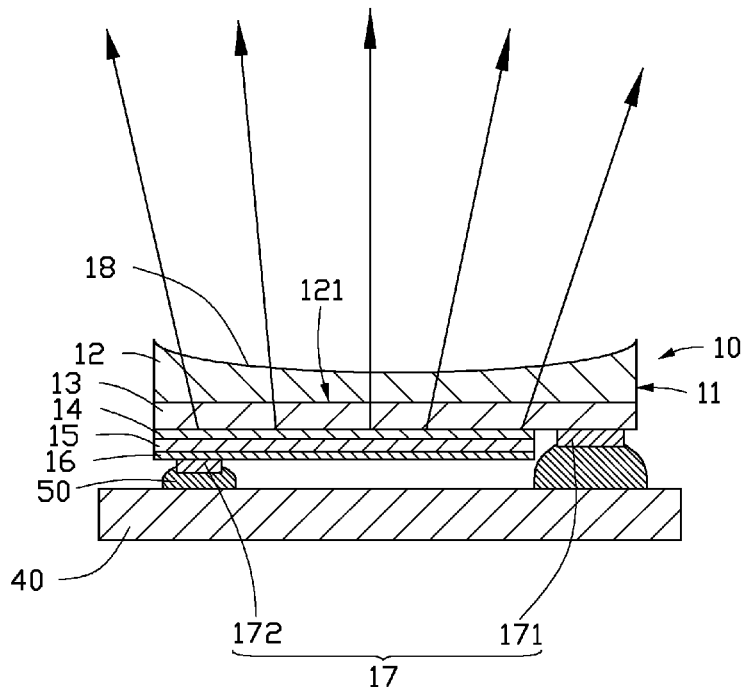
H01L 33/20 (2010.01)

F21S 8/10 (2006.01)

(52) **U.S. Cl.**

CPC **H01L 33/0095** (2013.01); **H01L 33/20** (2013.01); **F21S 48/1154** (2013.01)

9 Claims, 4 Drawing Sheets



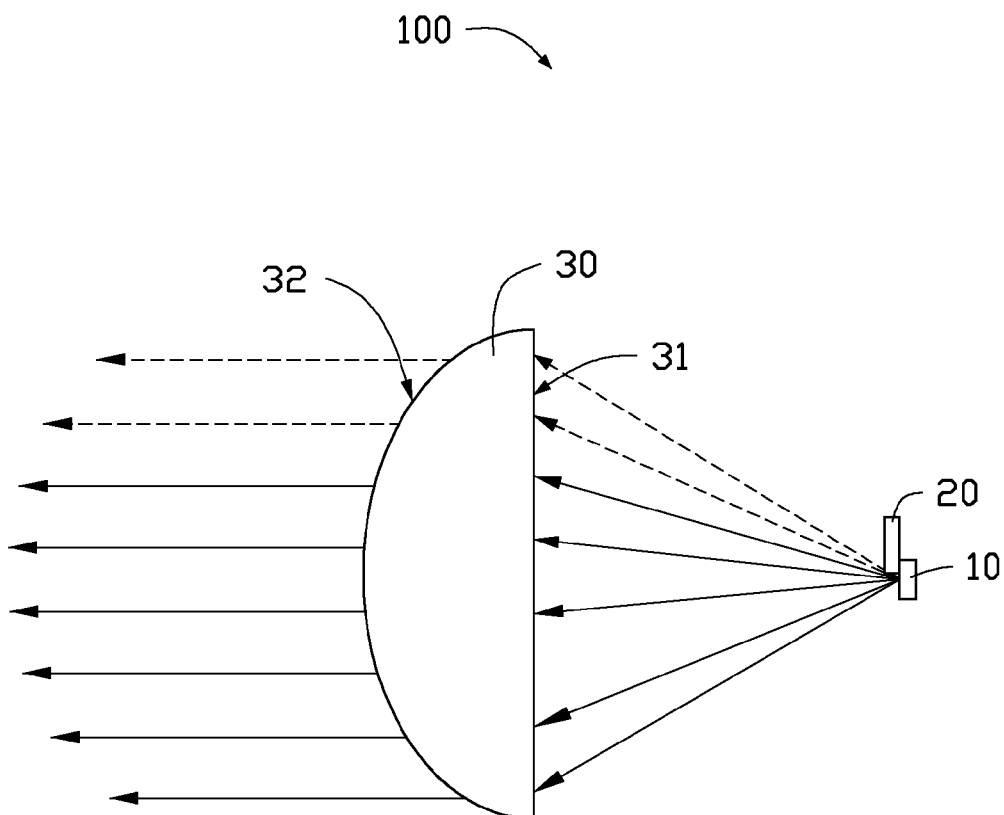


FIG. 1

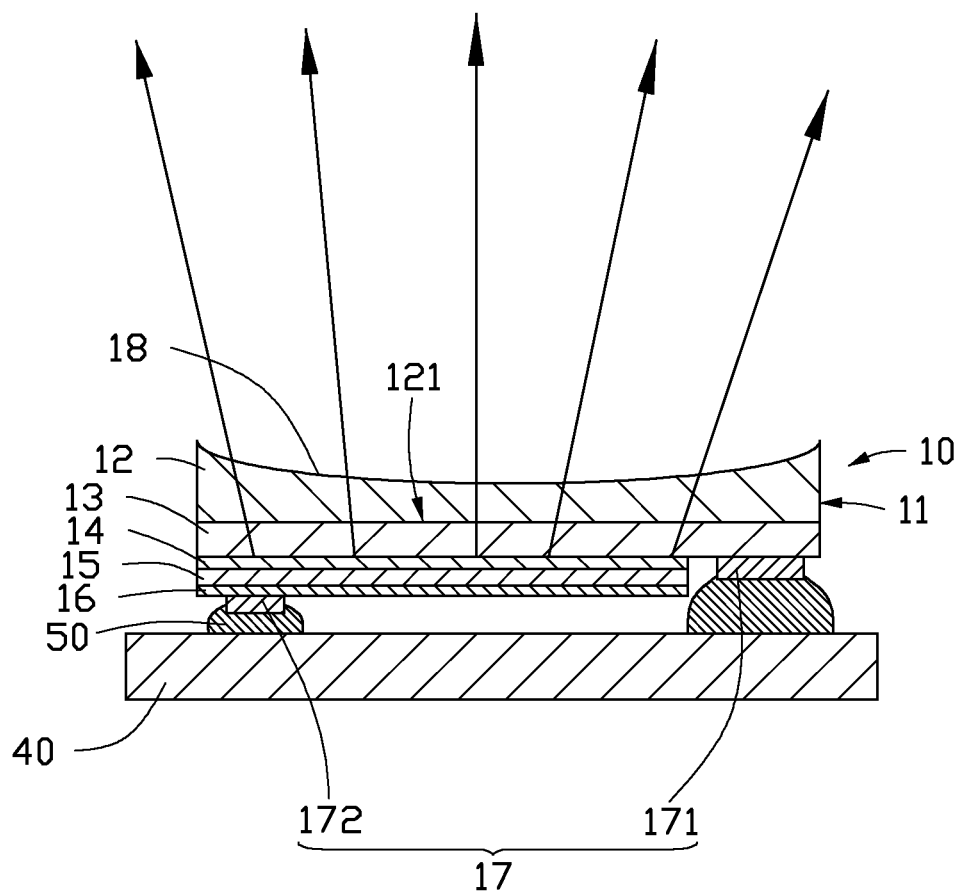


FIG. 2

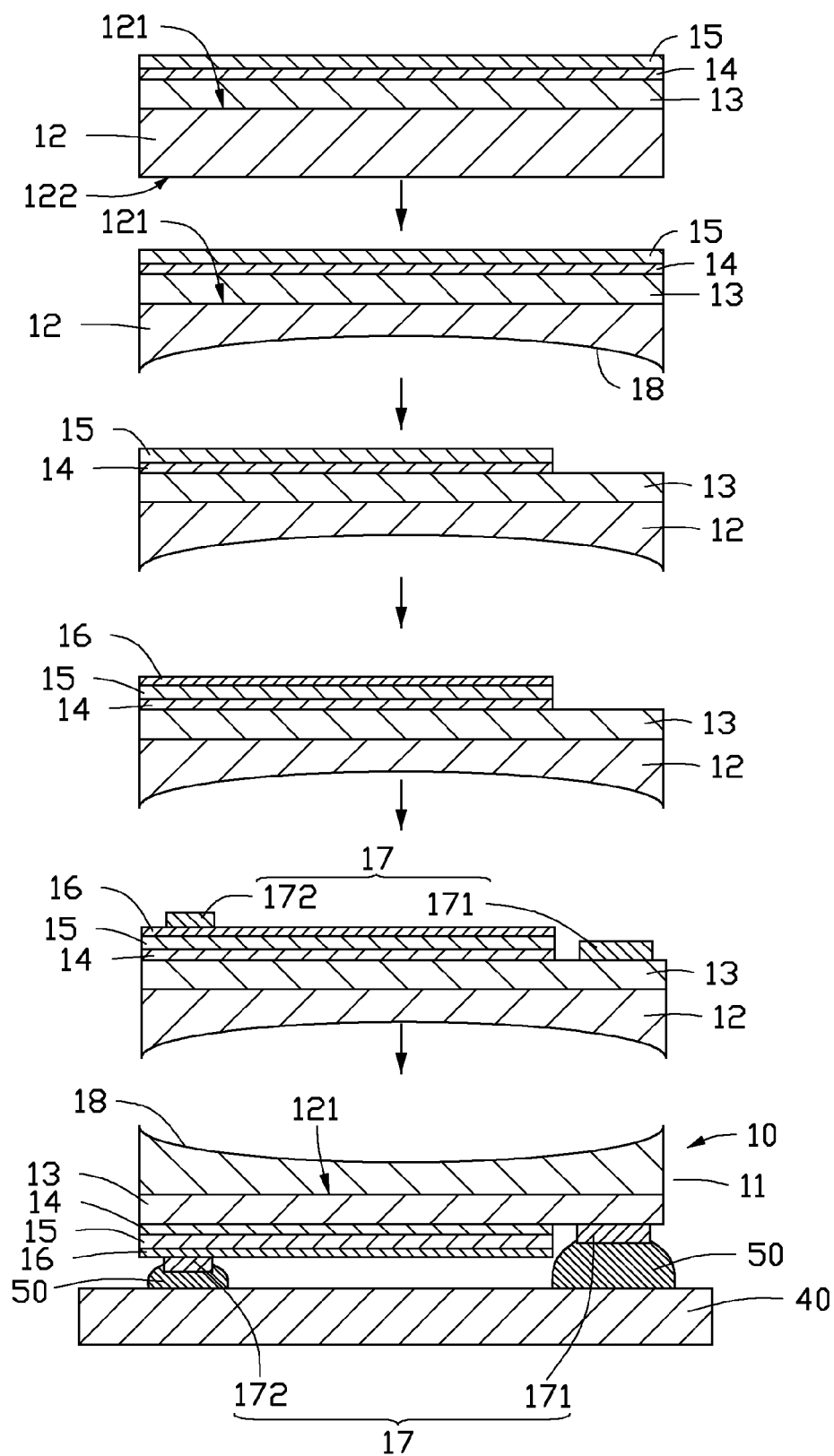


FIG. 3

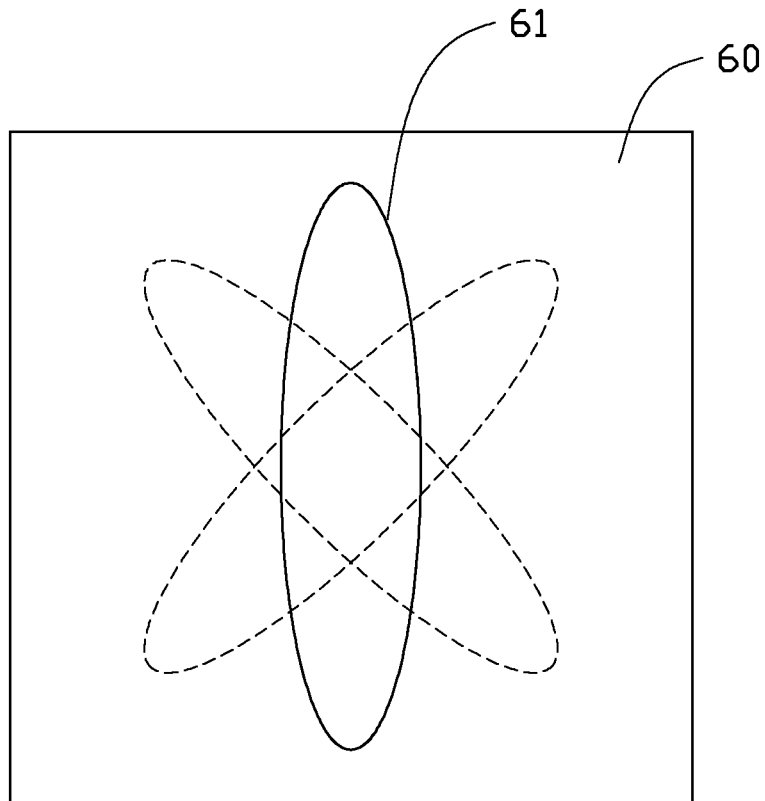


FIG. 4

1

LED DIE, METHOD FOR MANUFACTURING THE LED DIE AND AUTOMOBILE LAMP HAVING THE LED DIE

BACKGROUND

1. Technical Field

The present disclosure generally relates to semiconductor structure, and particularly to an LED (light emitting diode) die, a method for manufacturing the LED die and an automobile lamp having the LED die.

2. Description of the Related Art

LEDs have many advantages, such as high luminosity, low operational voltage, low power consumption, compatibility with integrated circuits, faster switching, long term reliability, and environmental friendliness which have promoted their wide use as a light source.

A typical automobile lamp structure includes an LED light source, a reflecting shell, a shading portion and a lens. The LED light source generally generates light with different brightness in a radiation angle, which leads to the LED light source and the lens can not be directly engaged together to obtain a light source with evenly brightness. Accordingly, light emitted from the LED light source should be reflected by the reflecting shell and converged to the shading portion firstly. The light is regulated to a preset shape and radiate to ambient environment through the lens. However, the reflecting shell enlarges a volume of the automobile lamp structure and increases a manufacturing cost of the automobile lamp structure.

Therefore, it is desirable to provide an automobile lamp which can overcome the above-described problems.

BRIEF DESCRIPTION OF THE DRAWINGS

Many aspects of the disclosure can be better understood with reference to the drawings. The components in the drawings are not necessarily drawn to scale, the emphasis instead being placed upon clearly illustrating the principles of the present automobile lamp structure. Moreover, in the drawings, all the views are schematic, and like reference numerals designate corresponding parts throughout the views.

FIG. 1 is a schematic view of an automobile lamp in accordance with an exemplary embodiment of the present disclosure.

FIG. 2 is a cross-sectional view of an LED die of the automobile lamp of FIG. 1.

FIG. 3 shows steps of forming the LED die of the automobile lamp of FIG. 2.

FIG. 4 is a schematic view of a light mask for laser etching the light outputting surface of the LED die in the automobile lamp of FIG. 2.

DETAILED DESCRIPTION

Referring to FIG. 1, an automobile lamp 100 in accordance with an embodiment is provided. The automobile lamp 100 includes a light source 10, a shading portion 20 and a lens 30.

Specifically, referring to FIG. 2, the light source 10 is an LED package and includes an LED die 11 and a packing structure (not shown) engaging with the LED die 11. The LED die 11 includes a transparent substrate 12, an N-type layer 13, an active layer 14, a P-type layer 15, a reflective layer 16 successively arranged along a top-to-bottom direction to the LED die 11, and an electrode structure 17 mounted on a bottom of the LED die 11.

2

The transparent substrate 12 is electrically insulating. Referring to FIG. 3, the transparent substrate 12 includes a first surface 121 and a second surface 122 opposite to the first surface 121. The second surface 122 is etched by laser to act as a light outputting surface 18. The light outputting surface 18 is concave. In this embodiment, the light outputting surface 18 is a smooth, arc-shaped structure. The transparent substrate 12 is made of sapphire.

The N-type layer 13, the active layer 14, the P-type layer 15 and the reflective layer 16 are successively arranged on the first surface 121. In this embodiment, the N-type layer 13 is an N-type GaN layer. The active layer 14 is a multiple quantum well (MQW) GaN/InGaN layer. The P-type layer 15 is a P-type GaN layer. Common ends of the active layer 14 and the P-type layer 15 are removed to expose a part of the N-type layer 13. The reflective layer 16 is flat and formed on a bottom surface of the P-type layer 15 to reflect light emitting from the active layer 14 for strengthening light outputting efficiency of the LED die 11.

The electrode structure 17 includes an N-electrode 171 and a P-electrode 172. The N-electrode 171 is arranged on the N-type layer 13, the P-type layer 172 is arranged on an edge of the reflective layer 16. The N-electrode 171 is above of the P-electrode 172. The N-electrode 171 and the P-electrode 172 electrically connect with a printed circuit board (PCB) 40 via solders 50. Light emitted from the light source 10 radiates out via the light outputting surface 18. The light outputting surface 18 diverges light from the active layer 14 when the light radiates through the light outputting surface 18.

The shading portion 20 is arranged between the light source 10 and the lens 30. A shape of the shading portion 20 is designed according to a luminance shape generated by the automobile lamp 100. Specifically, the shading portion 20 includes a side surface, and a shape of the side surface is the same as a cut-off line which complies with relevant law and regulations. When the light from the light source 10 reaches the shading portion 20, a part of the light is blocked by the shading portion 20, and the other part of the light passing through the shading portion 20 is regulated thereby to have a preset luminance shape with a cut-off line formed by the side surface. That is the shading portion 20 provides a cut-off line to regulate light generated by the light source 10 to the preset luminance shape. Thereafter, the light having the preset luminance shape radiates to ambient environment via the lens 30.

The lens 30 is a convex lens. The lens 30 includes a plane incident surface 31 and a convex light-emitting surface 32 protruding from a periphery of the incident surface 31 away from the shading portion 20. The light outputting surface 18 of the light source 10 directly faces the incident surface 31. The lens 30 is spaced from the shading portion 20 and the light source 10. The convex light-emitting surface 32 is a spherical surface.

When the automobile lamp 100 works, light radiates from the light outputting surface 18 and is diverged therefrom. As such, light generated by the light source 10 can be directly transmitted to the shading portion 20 and regulated to a preset luminance shape with the cut-off line and radiate to ambient environment via the lens 30. Accordingly, the automobile lamp 100 has a smaller volume since it can eliminate the necessity of a reflecting shell and the manufacturing cost of the automobile lamp 100 is accordingly decreased.

The disclosure provides a method for manufacturing the automobile lamp 100 which includes following steps:

Referring to FIG. 3, from top to bottom, first, a green LED die (not labeled) is provided, which includes a transparent

3

substrate **12**, and an N-type layer **13**, an active layer **14** and a P-type layer **15** arranged on the transparent substrate **12** in sequence.

The transparent substrate **12** is electrically insulating includes a first surface **121** and a second surface **122** opposite to the first surface **121**. The transparent substrate **12** can be made of materials such as sapphire, SiC, Si or GaN and so on. In this embodiment, the substrate **12** is made of sapphire. The N-type layer **13**, the active layer **14** and the P-type layer **15** are successively formed on the first surface **121**.

Referring to FIG. 4, a laser source (not shown) matching a mask **60** is provided to etch the second surface **122** to form the light outputting surface **18**, wherein the light outputting surface **18** has a smoothly concave, arc-shaped configuration. Specifically, the mask **60** is square and a patterned zone **61** is defined in a center of the mask **60**. The patterned zone **61** is a void and is elliptical in shape. The laser permeates through the patterned zone **61** of the mask **60** to etch the second surface **122** to form the light outputting surface **18**, during which the green LED die is rotated under to the mask **60**. Accordingly, the light outputting surface **18** is formed. In this embodiment, the laser is a KrF excimer laser with a small energy applying to the second surface **122** to precisely process the second surface **122**. Since the light outputting surface **18** is etched and formed by laser etching, the arc-shaped light outputting surface **18** can be easily formed; should the light outputting surface **18** be formed by a traditional etching method, for example, chemical etching, the arc-shaped configuration cannot be easily formed, since the traditional etching method is more suitable and likely to form a recess with a right-angled or a beveled edge.

Common ends of the active layer **14** and the P-type layer **15a** are then removed to expose a part of the N-type layer **13**. A reflective layer **16** is formed on the P-type layer **15**. A size of the reflective layer **16** is equal to that of the P-type layer **15**. In this embodiment, the reflective layer **13** is formed by plasma enhanced chemical vapor deposition method. The electrode structure **17** is arranged on the green LED die to complete the formation of the LED die **11**. Specifically, the N-electrode layer **171** is arranged on the exposed surface of the N-type layer **13**, and the P-electrode **172** is arranged on the reflective layer **16** at an edge thereof away from the N-electrode **171**. Accordingly, the LED die **11** is formed.

The LED die **11** is then reversed. The N-electrode **171** and the P-electrode **172** of the LED die **11** are soldered and electrically connected to the PCB **40**. Alternatively, a packing structure such as a resin with/without fluorescent particles doped therein can be used to encapsulate the LED die **11** to form the LED light source **10** after the LED die **11** is reversed.

The lens **30** is provided and spaced from the LED light source **10**. The incident surface **31** of the lens **30** is arranged to directly face the light outputting surface **18** of the LED die **11** of the LED light source **10**.

The shading portion **20** is arranged between the LED light source **10** and the lens **30** to regulate the luminance shape generated by the LED die **11**.

4

It is to be understood that the above-described embodiments are intended to illustrate rather than limit the disclosure. Variations may be made to the embodiments without departing from the spirit of the disclosure. The above-described embodiments illustrate the scope of the disclosure but do not restrict the scope of the disclosure.

What is claimed is:

1. A light emitting diode (LED) die, comprising:
 - a transparent substrate comprising a first surface and a second surface opposite to the first surface, a light outputting surface being formed on the second surface, the light outputting surface having a smoothly concave and arc-shaped configuration;
 - an N-type layer, an active layer, and a P-type layer sequentially arranged on the first surface of the transparent substrate, a part of the N-type layer being exposed, an electrode structure electrically connecting with the N-type layer and the P-type layer respectively.
2. The LED die of claim 1, wherein the transparent substrate is electrically insulating.
3. The LED die of claim 1 further comprising a reflective layer, wherein the reflective layer is arranged on the P-type layer.
4. The LED die of claim 3, wherein the electrode structure comprises an N-electrode and an P-electrode, the N-electrode being mounted on the exposed N-type layer and the P-electrode being mounted on the reflective layer.
5. An LED automobile lamp, comprising:
 - a light source comprising:
 - a transparent substrate comprising a first surface and a second surface opposite to the first surface, a light outputting surface being formed on the second surface, the light outputting surface having a smoothly concave and arc-shaped configuration;
 - an N-type layer, an active layer, and an P-type layer sequentially formed on the first surface of the transparent substrate, a part of the N-type layer being exposed, an electrode structure electrically connecting with the N-type layer and the P-type layer respectively; and
 - a lens spaced from the light source, the light outputting surface facing the lens.
6. The LED automobile lamp of claim 5 further comprising a shading portion arranged between the light source and the lens, wherein the shading portion provides a cut-off line to regulate light generated by the LED die to have a preset luminance shape.
7. The LED automobile lamp of claim 5, wherein the transparent substrate is electrically insulating.
8. The LED automobile lamp of claim 5, wherein the LED die further comprises a reflective layer, the reflective layer being arranged on the P-type layer.
9. The LED automobile lamp of claim 5, wherein the electrode structure comprises an N-electrode and a P-electrode, the N-electrode being mounted on the exposed N-type layer, the P-electrode being mounted on the reflective layer.

* * * * *